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WHY ANYTHING RATHER THAN NOTHING? THE ANSWER OF QUANTUM MECHANICS

Abstract: *Many researchers determine the question "Why anything rather than nothing?" to be the most ancient and fundamental philosophical problem. It is closely related to the idea of Creation shared by religion, science, and philosophy, for example in the shape of the "Big Bang", the doctrine of first cause or causa sui, the Creation in six days in the Bible, etc. Thus, the solution of quantum mechanics, being scientific in essence, can also be interpreted philosophically, and even religiously. This paper will only discuss the philosophical interpretation. The essence of the answer of quantum mechanics is: 1.) Creation is necessary in a rigorously mathematical sense. Thus, it does not need any choice, free will, subject, God, etc. to appear. The world exists by virtue of mathematical necessity, e.g. as any mathematical truth such as 2+2=4; and 2.) Being is less than nothing rather than more than nothing. Thus creation is not an increase of nothing, but the decrease of nothing: it is a deficiency in relation to nothing. Time and its "arrow" form the road from that diminishment or incompleteness to nothing.*

Keywords: *creation, quantum mechanics, being, anything, nothing*

Why Anything Rather than Nothing?

Many researchers determine the question "Why anything rather than nothing?" as the most ancient and fundamental philosophical problem (Wippel 2011). Some believe that this problem should be questioned first, before any other problem is tackled (Hoffman, Rosenkrantz 2010).

It should underlie what the primary substance of the world is: spirit or matter. The pathway from being to time was traced by Heidegger in his famous *Sein und Zeit* (1927), where he insisted on the "question of the meaning of the Being" as the beginning of philosophy. We will try to answer it, too, by means of science rather than strictly by means of philosophy. Nevertheless, we will find, as Heidegger, that time inherently links to being once the question "Why being rather than nothing?" is asked.

Three of the most fundamental domains of human culture – religion, physics and mathematics – have offered three quite different versions of the Creation. Our problem is very closely related to the idea of Creation shared by religion, science and philosophy (e.g. the "Big Bang", the doctrine of first cause or *causa sui*, the Creation in six days in the Bible, etc). In mathematics the "empty set", the mathematical equivalent to "nothing", is what is there in the beginning. From this starting point, it generates natural numbers, choice, sets, and all mathematical objects, complex or not. Mathematics, then, provides an example of how its world can be rigorously constructed on the grounds of "nothing". The concept of Creation generates big issues in physics, due to the following: the most fundamental postulate of physics – energy conservation – can be called a "no creation" axiom. Energy must conserve at all times, and thus anything physical, having by definition nonzero energy, cannot appear from nothing possessing zero energy for this would violate the rules of energy conservation. Furthermore, in different physics theories, time is conceived in two opposite ways inconsistent with each other: either reversibly (classical mechanics, relativity, etc.) or irreversibly (thermodynamics, etc.). The solution of statistical thermodynamics for time is very interesting and successful. It manages to resolve the contradiction of reversible time in mechanics and irreversible time in thermodynamics. According to statistical thermodynamics, the thermodynamic irreversibility is a result of the statistical averaging of mechanical reversibility. A huge part of information is lost after averaging and it is precisely that loss which generates irreversibility in thermodynamics. The loss of information in thermodynamics can be generalized by the notion of "hidden variables", which are hidden after averaging.

Quantum mechanics appeared as the domain of physics which generated new fundamental questions about the relevant way to reconcile reversible and irreversible time as a single consistent scientific theory. Quantum mechanics was forced to introduce the Planck constant, which is thermodynamic in essence, as fundamental to mechanical motion. Thus, its aim was to reconcile the reversible time of mechanics with the irreversible time of thermodynamics already present at its core.

Many scientists, even Einstein, expected that its solution should be similar to that of statistical thermodynamics. However, that conjecture turned out to be fundamentally wrong: "No hidden variables in quantum mechanics!" might have been the "slogan" of the solution for the reversible and irreversible time in quantum mechanics. Yet, the solution of quantum mechanics is partly analogical to that of statistical thermodynamics. In any single measurement [1], a great deal (exactly 50%) of information is lost. However, that loss is not due to averaging, or a result of human ignorance. It is a fundamental law of nature due to the limitations imposed by the Planck constant. That fundamental loss is caused by the passing of time in the final analysis. All rejected counterfactual alternatives might represent that necessary loss of information.

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In physics, two different, and possibly even two inconsistent conjectures exist about the "creation". The Big Bang is the most popular one. It postulates a special point in the creation (the "singularity" in t = 0), in which physical laws do not yet hold. However, these physical laws (both energy conservation and the reversible time of relativity) hold at any time thereafter. The viewpoint of quantum mechanics is different and rather similar to that of Descartes, mainly in his *Third*

[1] In fact, any quantum leap is determined unambiguously by both an initial and a final state. Thus, the number of necessary variables is exactly the same as in the classical case of smooth motion, and only as *types* of variables are there half of them, each occurring twice: once for the leap initial state, and once more for the leap final state. However, and unlike in the classical case, that exhausting number of variables is not accessible in any single measurement, but in two separate events. Thus, a new problem appears as far as Heraclitus' "No man ever steps in the same river twice, for it's not the same river and he's not the same man" holds. Continuing the metaphor of Heraclitus' "river", quantum mechanics is forced to describe all states of both "river" (i.e. the investigated quantum entity) and "man" (i.e. the apparatus together with the experimenter), which might happen in the future. This description is the wave function of the entity at hand. The wave function refers to only half of the variables in comparison to the classical case, but the information attributed to them is doubled for the wave function is complex rather than real. From that viewpoint, hidden variables in quantum mechanics cannot exist since the information is exactly the same as in the classical case. Half of the information is lost only after measurement and then secondarily restorable as a probability distribution of all states of both "man" and "river" in a series of measurements.

Meditation (Descartes 1641; Husserl 1931; Мамардашвили 981; Secada 1990; Gorham 2007, 2008): creation is permanent at any time and it is due to the irreversibility of time. If one projects all irreversibility of time into a single point of the beginning, the well-known picture of the Big Bang will appear. One can search for empirical confirmations regarding the Big Bang. If the Big Bang were real, it would be impossible for any physical objects in the universe older than the universe itself to exist. However, if the Big Bang is not real, but only a hypothetical projection of the irreversibility of time into a single zero point, it may be an averaging of the course of time in all points in the universe. Arbitrary deviations from that average quantity would exist in various spots of the universe. Most objects may be younger than the universe, but at least a few ones should be older than it. The existence of objects older than the universe has been partly[2] confirmed through experiments (Chamberlain, Aller 1951; Spite, Spite 1982; Molaro 1987; Bond et al. 2013).

Various interpretations of the solution of quantum mechanics might exist analogically. Thus, the solution of quantum mechanics, being scientific in fact, can also be interpreted philosophically, and even religiously. Indeed, the opposite conjecture of the Big Bang was elaborated by the Belgian Catholic priest Georges Lemaître (1927; 1931; 1946) as early as 1927. It was able to reconcile science (from the Big Bang onwards) with religion (the Big Bang itself as God's Creation). Analogically, the solution of quantum mechanics admits religious interpretations. However, only the philosophical and mathematical interpretations are discussed here. Its essence is: creation is permanent and due to the irreversibility of time; it is mathematically necessary. Thus, it is not due to one's free will (e.g. God's, the observer's, etc.). It is not an addition, but rather takes away due to the rejection of the reverse "half" of time. Being is less than nothing.

The viewpoint of quantum mechanics on the creation reveals the following. The essence of the answer of quantum mechanics (in physical terms rather than in philosophical notions) is: the CPT-theorem is fundamental (Bell 1955; Pauli 1955; Luders 1954) because it manages the

[2] The contemporary accuracy of measurements does not allow for any unambiguous statements: they may or may not really be older than the universe. However, the dominating paradigm of the "real Big Bang" has a very strong influence on the formulation. Therefore, all publications emphasize that those objects appeared very soon after the Big Bang, rather than right before it, though the experimental accuracy allows for both kinds of interpretation.

transformation of the discrete charge (electric and color charge, weak isospin) into a space-time position. Thus, it manages how the discrete transformation of elementary particles is equivalent to a continuous space-time trajectory. Weak (or the unified electro-weak) interaction manages the mechanism of how discrete charges can be transformed into space-time trajectories. Weak interaction implies that the Higgs mechanism (Englert, Brout 1964; Higgs 1964; Higgs 1964a; Guralnik, Hagen, and Kibble 1964; Glashow 1961; Anderson 1963; Gilbert 1964; Streater 1965; Higgs 1966) generates mass (energy) at rest by cutting the opposite direction of time [3].

Therefore, mass (energy) at rest represents the total probability of all cut alternatives after the unavoidable choice in the course of time. The antiparticles (with opposite charges) represent the "difference" of the particles compared to the physical "nothing" (which is not a vacuum, but the result of their physical annihilation). Thus, particles identical to their antiparticles (such as photons, Z^0 bosons, π^0 mesons) represent the physical nothing from the viewpoint of the physical being (which may be defined as possessing any nonzero mass at rest) [4].

What the Higgs mechanism moving within the pole of "first philosophy" means is very simple, but hardly obvious: the nothing is unstable. It breaks down "spontaneously", i.e. by itself. All being is due to that fundamental instability of the nothing, and thus that instability should underlie the concept of creation. The answer to our initial question "Why anything rather than nothing" is: because the nothing is unstable. However, there is one even more fundamental question: "Why is the nothing unstable?" The question seems not to allow a direct physical answer. It needs a *mathematical* reason that could be revealed in the foundation of mathematics – in set theory – and will be discussed

[3] A complex relation between "choice" (the axiom of choice) and the imaginary and real domains of Minkowski space utilized by special relativity on the one hand, and the complex separable Hilbert space utilized by quantum mechanics on the other hand, is available. Namely: by means of the axiom of choice, the imaginary domain may be mapped isomorphically into that Hilbert space, thereby cutting the real domain equivalent to the opposite direction of time, or in other words, choosing the imaginary domain of Minkowski space.

[4] The "boundary" of the physical nothing between particles and antiparticles is, in a sense, conventional. Theoretically, this could be any state. In fact, this state is determined unambiguously by the three most fundamental physical constants: the Planck constant, the light speed in vacuum, and the gravitational constant. It may be considered as "zero" only ontologically, for those constants imply nonzero physical parameters for it.

as the mathematical necessity of creation later in the article. What the Higgs mechanism discusses immediately is how the elementary particles corresponding to the weak and strong fields, unlike those of the electromagnetic field, acquire their nonzero mass at rest – something that all experiments confirm. Furthermore, it discusses the way for all possessing nonzero mass at rest to acquire it. Consequently, the Higgs mechanism elucidates how matter in a physical sense always appears. It follows that the pole of ontology can be represented as follows: time and its "arrow" are what break down the symmetry by rejecting the opposite direction of time [5]. Everything that is rejected as belonging to the opposite direction of time is represented in the actual course of time as that mass at rest, and this is the way for it to appear from the nothing, i.e. as if it is a "byproduct" of time.

Quantum mechanics can be considered as a cognitive "microscope" for investigating the correct genesis for that asymmetry of time. Indeed, it is a theory of how irreversible time appears physically from the coherent and reversible quantum state. Both electromagnetic and strong interactions as well as gravity in a sense share CT-symmetry implying P-symmetry as a separate and independent symmetry for the total CPT-symmetry. In that particular framework, only the antiparticles represent the opposite direction of time in the coherent "primordial soup" of being, just as in the process of how the "arrow of time" appears. The weak interaction complicates the above picture adding P-asymmetry to C-asymmetry to represent the appearing T-asymmetry in the still coherent "primordial soup" of being. Where is the room for gravity in breaking down the symmetry? Indeed, there are two different conceptions about mass of rest: the first, according to the Higgs mechanism following how it appears; the other, according to general relativity, as it interacts. Both "kinds" of mass at rest should be equal to each other in a generalization of the "equality of inertial and gravitational mass": the former in the Higgs mechanism, and the latter in

[5] The physical meaning of that ontological viewpoint is the following: The violation of symmetry is forced by the different physical dimensionality of Minkowski space corresponding to the light speed in vacuum, and thus to "speed", and of the utilized Hilbert space corresponding to the Planck constant, and thus to "action". The gravitational constant is what adds a second equation to the relation of their dimensionality, therefore determining that violation of symmetry unambiguously. As far as the real domain of Minkowski space, equivalent to the opposite direction of time, is cut for the transformation of the former into the latter space, one may say that the cut direction of time is represented implicitly in the gravitational constant and then, by any mass involved in gravitational interaction.

general relativity. The following is an approach to both Higgs and gravitational mass at rest (and their eventual unification), which discusses the way for the opposite (rejected) direction of time to be represented in general relativity.

One has to start from special relativity, in which the "normal" direction of time is represented by the subliminal (or "imaginary") domain in Minkowski space, and the "opposite" direction, by the superluminal (or "real") one. The change in direction of time means the exchange between the two domains as well as the T-symmetry. If one utilizes the conjecture that general relativity can be considered as the generalization of special relativity in relation to the superluminal domain (Penchev 2013), the change to the opposite direction of time means involving the subluminal domain of pseudo-Riemannian space in the superluminal domain of Minkowski space. In the pole of ontological reflection, this means that all information lost due to rejecting the opposite direction of time is represented anyway in the "normal" course of time. However, this occurs in the total form of mass (energy) generated by the transformation of Minkowski space into pseudo-Riemannian space and results in gravitational interaction. The transition from the forward (for us) to the opposite direction of time, as well as the reverse transition from the opposite to the forward (for us) direction of time, results in one and the same pseudo-Riemannian space, one and the same general relativity. Mass and energy in general relativity are only positive and only generate attraction: the change in direction of time does not imply antigravity: it seems not to exist. Following CT-symmetry, one may notice that the mass of all antiparticles is identical to that of the corresponding particles, their counterparts.

Thus, general relativity discusses the *ultimate* result after the direction of time is established as what is conceived to be forward for us. On the contrary, quantum mechanics means the "primordial soup" of a partly, in general coherent state, in which both directions of time co-exist, and the asymmetry of time, the "arrow of time", is still in the process of its constitution and obeys CPT-invariance. Thus, the viewpoint of general relativity is disjunctively alternative to that of quantum mechanics, as well as, in a sense, equivalent to it. However, the choice of the opposite direction of time leads to a universe identical to ours. All antiparticles exist only in the "primordial soup" of quantum coherent states. All of them result in the total mass (energy) in the normal course of the ultimate "arrow" of time. The C-symmetry, T-symmetry, and

P-symmetry are decomposed from the "primordial" total CPT-symmetry and each of those three symmetries is reduced to idempotency: the "antiparticles" coincide with the particles; the opposite direction of time coincides with the normal one, and space is isotropic.

Electromagnetism can visualize that transition if one admits both electric charges situated just "before the boundary" of the ultimate "arrow" of time, and the single magnetic charge as the result of the identification of both electric charges just "after the same boundary". That illustration can serve as a metaphor of how the Higgs mechanism in the "primordial soup" of time is transformed into the mass (energy) of general relativity after the ultimate constitution of the "arrow" of time.

The "dark"problems

However, there exist two huge "dark" problems concerning the equality or equivalence of the Higgs mechanism to the mass (energy) of general relativity: "dark matter" and "dark energy". "Dark matter" (Trimble 1987: 451-452) consists of the experimentally very well corroborated fact (Ade 2016) that the angular speed of rotation of huge celestial objects such as our galaxy, the Milky Way, exceeds many times the speed allowed according to the total mass of the visible matter in the object at issue (e.g. the Milky Way). In other words, almost all huge celestial objects such as galaxies, star clusters, nebulae, etc. should break down and flush in all directions due to the centrifugal forces of their rotations. However, nothing of this sort has been observed. The only possible, or at least the most probable explanation according to contemporary science, is the presence of hidden or "dark" mass and matter, which has not been visible until now, not even in principle. Furthermore, this hidden matter should possess about 5.47 times more mass than the usual, visible mass. Of course, this conclusion is shocking since it means that our physical cognition refers only to a relatively insignificant part (about 18.3%) of the universe. Nevertheless, all experimental observations confirm this fact.

All mass due to the Higgs mechanism, as well as all elementary particles, are observable. Unlike all this, dark matter can be revealed only by its gravitational effect preventing the action of centrifugal forces.

"Dark energy" (Riess et al. 1998: 1009) consists of the very well confirmed fact[6] that the expansion of the universe is accelerated: the

[6] The Dark Energy Survey: https://www.darkenergysurvey.org/the-des-project/

speed of its expansion increases permanently. According to the level of contemporary physical cognition, this means that a large, unknown amount of energy is pouring into the universe at any given moment in time. This is "dark energy". Both dark energy and dark mass are "dark": this means that their existence is established only indirectly by means of their effect, but they seem not to be directly observable, at least up till now. However, dark matter is a static "dark" effect, while dark energy is a dynamic one. The total amount of dark energy in the universe is a few times more than dark matter and more than ten times more than visible matter and energy. The experimentally confirmed proportions are: visible matter and energy comprise 4.9%; dark matter, 26.8%; dark energy, 68.3%. So, the existence of dark energy is even more striking than that of dark matter. The metaphor that the "shore of our knowledge" is much less than the "ocean of our ignorance" is very appropriate when speaking about dark matter and dark energy.

The attempts to explain those "dark" phenomena might be distributed into two basic groups: "standard", by means of the Standard model; or "non-standard", by means of theories or experimentally observed phenomena from the framework of the Standard model. Confinement or "color confinement" is one of the main conjectures among the standard explanations of the dark phenomena. It means a mysterious, hypothetical force which holds on to the quarks linked very strongly to each other, preventing them from being observed on their own. The hypothesis is that it increases proportionally (even exponentially) at a distance, unlike all known and observable forces in nature decreasing at a distance. This is how the confinement might explain dark energy. The expansion of the universe is a process of positive feedback since the expansion itself generates energy by means of the mechanism of confinement. In other words, the dark energy is equivalent to the expansion of the universe and thus, it is self-accelerating in and of itself. In turn, dark matter might be a static phenomenon of dark energy, due to the current amount of energy in any huge rotating celestial object such as our Milky Way.

The main objection is that the degree of tension due to color confinement has an upper limit, after which the color interaction breaks, just as an over-extended elastic spring breaks, and therefore a "colorless jet" of hadrons appears: the so-called hadronization of quarks or gluons. That "jet" tends to expand further and further in time because the color interaction in any new colorless hadron has been extending

overview/

in turn until it "breaks", too, and generates more new quarks or gluons, which are hadronized again immediately and unobservably[7].

Our key question should be what happens with energy conservation during the process of hadronization: the energy of the "broken over-extension" passes into the mass-energy of the generated ("from the vacuum") anti-counterparts for any quark or a pair of quarks and antiquark for any gluon. This can explain how the space extension itself can generate energy by itself by means of color elementary particles such as quarks or gluons and the extraordinary property of color confinement transforming the extension of the universe into a kind of "perpetuum mobile". The process of hadronization may further illuminate the intimate mechanism of how time appears from space over the upper limit of its allowed extension. The space extension generates energy for color confinement. That space extension breaks over a certain energetic bound and a hadron jet appears. Any element of the hadron jet turns out to be doubled by a pair of quark and antiquark, and hadronization obeys the first of all strong, and electromagnetic interaction. Both are CT-invariant, and P-symmetric because of CPT-invariance. As all the Standard models, they are Lorentz-invariant, which is very closely linked to the CPT-invariance. Thus, any pair of quark-antiquark can be considered equivalent to a single particle doubled in both directions of time[8]. Those "two directions of time" appear to exceed

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7 The only exception is the top quark, whose time of decay is supposed to be less than the time necessary for its hadronization, so the products of its decay can be observed and thus indirectly, the top quark itself is as if "bare" (Abachi et al. 1995; Abe et al. 1995).

8 One can consider motion at a velocity as the elastic extension of space. Then, the speed of light is the upper bound: a limit, after which the space is "ruptured" into parts, e.g. into particles such as an electron and a positron. On the contrary, the Planck constant is the minimal possible action between two or many parts, in which those "parts" (ostensibly) are necessarily a single whole. So, both the speed of light in vacuum and the Planck constant are boundaries between discreteness and continuity in a physical and thus experimental sense. Nonetheless, they are absolutely independent from each other; even their physical dimensionalities are different. One may further imagine the special case where the one criterion for discreteness is satisfied, but the other one is not. The quark's inability to exist alone seems to fit right into that intermediate or "conflict" area between the two different boundaries separating discreteness and continuity. As far as they interact with each other and can interact with other elementary particles both by strong and by electromagnetic interaction, the Planck constant seems to be exceeded, but in the special case of quarks, the speed of light is not. This seems to be the essence of confinement from the present viewpoint.

the upper limit of allowed space extension: time seems to appear for the limitation of spatial "elastic" extension [9].

There are at least a few objections against color confinement as a possible source of dark matter and energy. It is still only an ad hoc empirical hypothesis explaining a series of phenomena studied by quantum chromodynamics very well, but it cannot be deduced mathematically from the formalism of quantum mechanics and quantum chromodynamics. It is corollary from one of the seven "Millennium Prize Problems", namely the "Yang–Mills and Mass Gap" problem [10]. "Color confinement" is not yet described well enough quantitatively and theoretically, but rather qualitatively. Thus, the origin of the energy transformed into hadrons after hadronization is not elucidated: that kind of energy is instead only postulated ad hoc for the abundance of corroborating experimental data. Furthermore, there exist essential problems about untarity or the Lorentz invariance of hadronization.

The main "nonstandard" conjecture about dark matter or dark energy is the phenomenon of entanglement. Entanglement is a phenomenon suggested by Einstein (together with Podolsky and Rosen) in 1935, in a famous article (Einstein, Podolsky, and Rosen 1935) as the refutation of the completeness of quantum mechanics, and independently by Schrődinger in the same year (Schrődinger 1935). Today, entanglement is very well corroborated experimentally [11]. In Einstein's words, it is a "spooky action at a distance" meaning that it should be neither Lorentz invariant nor unitary. Roughly speaking, one may say that it transfers only "pure" information about a certain quantum state (called "quantum information") at any distance instantly without any carrier possessing a certain nonzero amount of mass or energy. Even more mysterious: any other elementary particle such as an electron or a photon changes its state after it has obtained that "secret message" from its entangled counterpart(s). This makes it seem as if an electron or a photon, or any other elementary particle, has a "free will" in making a decision about how to change its state after the quantum message has been obtained

[9] The pair of a quark and an antiquark may be interpreted as rupturing the space by exceeding the "second" barrier, namely that of light speed, and thus rupturing the intimate link of the two directions of time, by which time appears properly. As far as all quarks in definition (or in virtue of confinement) cannot exceed that second barrier, they vanish instantly either by hardronization (most often) or by decay (only the top quark).

[10] http://www.claymath.org/millennium-problems

[11] The number of confirming experiments is huge (a brief overview e.g. in: Wiseman 2015).

by it. There even exist two "free will theorems" in quantum mechanics (Conway, Kochen 2006; 2009) stating that if the experimenter, a human being, possesses that "valuable commodity" of free will, this implies that any electron or any quantum entity with which the experimenter deals necessarily possesses the same "valuable commodity".

It is this very same idea (about the "free will of an electron") that made Einstein declare, in a letter to Max Born, that he would prefer to be a "croupier" or a "shoemaker" rather than a physicist if this were to be true (Born 1969: 118). The cited theorems correctly and expressively state the "free will of an electron". Therefore, it is possible that Einstein did not possess "free will" when deciding what would be his profession (this being a not less paradoxical solution of the problem).

However, a much more ordinary interpretation of entanglement, without any curious, pictorial, or even ridiculous presentations as presented above, is possible. Entanglement is a new form of physical interaction which is both non-unitary and Lorentz non-invariant, and generalizes the concept of physical interaction to certain physical instantaneous actions at any distance (i.e. in a zero time, or in other words, as if out of time), and (quantum) information is equivalent to physical action as far as the Planck constant exists. So, the electron does not "decide" how to change its state after having obtained the corresponding (quantum) information, but this information changes its state both directly and instantaneously by being itself equivalent to physical action . What seems to be "free will" is the direct physical action of information, for the information comprises the quantity of choices (and indeed, measured in units of elementary choices, what the bits are), and therefore information can in a sense be considered as the "quantity of free will".

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All three interactions (electromagnetic, weak, and strong) in the Standard model are both unitary (energy conservation) and Lorentz invariant (not exceeding the speed of light in vacuum). On the contrary, entanglement, if one considers it as a new physical interaction, is neither unitary (its energy is indefinite) nor Lorentz invariant (it is instantaneous, therefore exceeding the speed of light in vacuum). The only other known physical interaction, which is neither unitary nor Lorentz invariant, is gravity according to general relativity, which is the best confirmed theory of gravity, even without any "anomaly". Indeed, it is not unitary for energy does not conserve (what is conserved according to general relativity is energy-momentum, and therefore the energy itself is indefinite in general). It is not Lorentz invariant because the pseudo-Riemannian space of general relativity is arbitrarily (and even differently at any point in general) "curved" to the Minkowski space of special relativity. Perhaps Bronstein (Бронштейн 1936) was the first who demonstrated that gravity can be only locally quantizable since it is only locally unitary and Lorentz invariant, due to its continuity and smoothness, but generally not globally. According to him, only weak gravitational fields are approximately quantizable, and any gravitational field from all singularities is locally "weak". At last, one may build a one-to-one mapping, possessing a clear physical meaning, of the superluminal ("real") domain of Minkowski space into the subluminal ("imaginary") domain of pseudo-Riemannian space (Penchev 2013). The sense of that mapping is the interpretation of gravity as entanglement and vice versa [12]. Both dark matter and dark energy are revealed by gravitational phenomena for very huge celestial objects, the behavior of which is described by general relativity. So, if one may equate entanglement to gravity, entanglement turns out to be a possible source of dark matter or energy, e.g. as the corresponding equivalent mass at rest and gravitational energy. Indeed, entanglement satisfies the condition of being "dark" for it falls outside of the Standard model describing all as "visible".

The explanation of dark energy by means of entanglement can be the following:

The process of decoherence of any entangled state would mean the disappearance of entanglement and its degree of non-unitarity (or Lorentz non-invariance) equivalent to a certain mass (energy) in terms of general relativity. That energy can be called "energy of decoherence" therefore specific for any entangled object and "emitted" in space at any time in virtue of the decoherence itself. That energy is "pure" without

[12] The usual interpretation of entanglement in terms of general relativity (e.g. Jensen, Karch 2013) is as, or by means of, a "wormhole" in space-time (Einstein, Rosen 1935). For if one means that kind of usual interpretation, any quantum leap in space-time corresponds to a certain, "straight" wormhole "through" space-time. From our viewpoint, this wormhole is equivalent to a certain curvature in space-time (representable by a space-time tensor) and thus to a certain mass-energy (representable by an energy-momentum tensor equated to the former by the Einstein field equation) generating that space-time curvature. A certain common measure of both straight wormhole and curvature (and very roughly speaking, their length) has to be the same for that equivalence to hold. The concept, for example, of "holographic duality" means something similar in the framework encountered the interpretation of entanglement as a wormhole.

any source in the framework of the Standard model for entanglement is out of it, and therefore "dark". More than that, it is "dark" in principle as well, for it does not have any carrier in definition, originating directly from quantum information equated to a physical action by means of the Planck constant.

The equivalence of gravity and entanglement by general relativity is the necessary condition for that explanation of dark energy. If this were accepted as true, dark matter would correspond to the current degree of entanglement as an equivalent amount of mass at rest which also falls outside of the Standard model, unlike the Higgs mechanism [13], and directly (non-unitarily and Lorentz non-invariantly) originates from quantum information. This means that the process of decoherence transforms dark matter into dark energy as matter and energy are equated to each other by either special or general relativity: the amount of dark mass should decrease by the same amount, by which the amount of dark energy increases.

All physical interactions are able to generate entanglement [14], and

[13] The Higgs mechanism seems to correspond to the gravitational constant and thus to the unambiguous determination of the relation of Minkowski space and Hilbert space at issue. On the other hand, their relation (or difference) consists mathematically in two members: (a) the real domain of Minkowski space; (b) the axiom of choice for the discretization of Minkowski space to the separable complex Hilbert space as an equivalent. To be "equated" those two members, three physical members known until now and possibly partly or thoroughly overlapping each other should appear: gravitational constant & general relativity as well as entanglement. If one grants dark matter & energy to entanglement (as us), it is logically necessary either the Higgs mechanism to allow for a "dark part" (out of the Standard model) or it to be complemented by an additional, yet unknown part to the difference between Minkowski and Hilbert space in question. The problem seems to be directly linked to that of the "cosmological constant" (Einstein 1918) or "Mach's principle" (Einstein 1918: 241) in general relativity, and thus to the expansion of the universe, the "Big Bang" and (ostensibly) "Einstein's biggest blunt" (Gamov 1970: 44). If one admits (as us) that (quantum) information is able to cause physical action out of time (space-time) by entanglement, "Mach's principle" is rejected. Then, the cosmological constant is not necessary, but anyway both possible and consistent as well as the expansion of the universe and even eventually the "Big Bang" as a real event.

[14] Indeed, any interaction implies a force acting to any entity participating in the interaction, and thus causes a certain acceleration according to its mass (energy). That acceleration is able to be transformed partly as (or in other words, represented by) different degrees of entanglement between entities in the interaction. In a sense, the entanglement of the interaction is transformed equivalently into the acceleration of the entity at issue, and vice versa. The essence of entanglement and acceleration is one and the same from the viewpoint of quantum information, to which the option

it is still unclear how the balance between ordinary and dark matter and dark energy over the course of time might change. For this, a special theory of mutual transformation between them is needed, as well as many observations and experiments.

What one might say unambiguously is that dark matter decreases by transforming into dark energy, which increases. However, the amount of new dark matter for new entanglement due to the "visible" interactions remains absolutely unknown, and therefore the same goes for the general balance and change. Perhaps color confinement will take an essential place in that general balance [15].

The creation due to mathematical necessity

One can approach the mathematical necessity of creation as follows: the creation is necessary in a rigorous sense after one has mathematically represented the physical creation by "taking away". The operation $A \rightarrow \{A\}$ (i.e. the generation of a set from a class) means "taking away", and it is always possible, including the application to $\varnothing$ (the empty set) or to another set: $\{A\} \rightarrow \{\{A\}\}$. However, choice from the empty set is not allowed. Thus, choice turns out to be secondary to the natural numbers. They are implied directly and thus, necessarily, from the nothing for choice is implied only indirectly by means of them and by the axiom of choice, which does not include the choice of the empty set. That secondarity of choice is just that which implies the necessity of creation, for the creation comes "before" the choice appears. The choice appears together with time, however creation is outside of time, for the creation creates the time along with all the rest. The creation underlain by set theory seems to be leap-like, generating all natural numbers as the result of that necessary leap from nothing into being. On the contrary, physics describes the same equivalently, but alternatively: as a continuous process of the being to appear, which is observed as the expansion

of their mutual transformation is due.

[15] Confinement and entanglement seem to be similar to each other in a sense. Unlike the usual physical interactions between objects separate in both Minkowski and Hilbert space, the objects interacting either by entanglement or confinement are absolutely separate only in the one of them correspondingly. Entanglement is possible both by violating Bell's equation (over the light barrier) or not (below it). The criterion for the partial inseparability of quarks in Minkowski space is their fractional electric charge. At last, one may admit that a phenomenon (e.g. Lewkowycz, Maldacena 2014) as the entanglement of quarks (color entanglement) might exist to complement that scheme of partial separability and inseparability in different senses. That color entanglement might be linked to dark energy, too (e.g. Banerjee et al. 2005).

of the universe. In other words, the expansion of the universe is right in its appearance as the appearance of the being. However, the result of that process (the natural numbers) is given (or "granted") in advance. The creation (and quite particularly: the corresponding "principle of least action" in mechanics) suggests teleology as a certain aim, which is predefined in virtue of its necessity and embodied in the necessary appearance of the natural numbers from the empty set as an equivalent of the "nothing" to mathematics. In other words, the visibility of teleology can be understood as a "by-product" of the secondarity of the choice.

The operation, which is the generation of a set from the "nothing", implies all natural numbers by the construction described in the "axiom of infinity" in set theory. The set of all natural numbers is infinite, though all natural numbers are finite according to the axiom of induction in Peano arithmetic. That last circumstance needs elucidation. First, we must understand how the axiom of induction implies that all natural numbers are finite. The unit is finite. By adding a unit to any finite number, another finite number is obtained. If both premises are true, the axiom of induction implies that all natural numbers will be finite. Furthermore, the set of all natural numbers is infinite though all natural numbers are finite. One could argue that the wholeness of all natural numbers, which is what is meant by the concept of a set, implies a new different, "emergent" property, namely to be infinite. This is in contrast to the natural numbers, constituting that wholeness, which are finite. However, as above, that wholeness, perhaps as any wholeness, is obtained by taking away from rather than by adding to the natural numbers: finiteness turns out to be more than infinity, just as finiteness turned out to be less than the "nothing", as described in the empty set earlier.

One can say the following about the secondarity of choice: any set may be enumerated (the well-ordering principle), which means that it may be mapped one-to-one into some subset of the set of all natural numbers. The empty set can be enumerated by the special natural number "zero". The well-ordering principle implies the axiom of choice: this is meant as the secondarity of choice. Thus, the being does not need any choice, free will, subject, God, observer, etc. to appear for it appears in virtue of mathematical necessity. The creation can be considered as a mathematical truth. The world exists in virtue of mathematical necessity, e.g. as any mathematical truth such as "2+2=4". However, that fact requires the completeness of the being, which is not demonstrated yet, e.g. as follows: the operation $A \rightarrow \{A\}$ can be interpreted as a "primary choice", and thus a vicious circle appears. The vicious circle being equivalent to a contradiction generates an empty set, to which it is a characteristic property. That empty set can underlie the successive genesis: "A → {A}" as a choice means an alternative "A → {B}" exists, e.g. {B}=∅: that choice would be necessary only if {A}={B}=∅, i.e. "nothing → ∅" is necessary.

In a sense, the being is less than nothing. The being is less than nothing, rather than more than nothing. The creation does not add, but takes away. This seems to be paradoxical to common sense. It may be visualized particularly by an example. Any contradiction (such as A ∧ ¬A) as a characteristic property defines the empty set. If one removes either A or ¬A, an non-empty set can in general be defined by means of either ¬A or A correspondingly as two separated characteristic properties. Furthermore, the mathematical necessity of the being is also consistent with the conception of the Big Bang. We discuss the gradual physical creation at any time, due to the irreversibility of time as mathematically necessary. However, the mathematical necessity of the being underlies the "Big Bang" too. Time implies energy in virtue of Emmy Noether's theorems (1918). The well ordering generates the axiom of choice and thus choice itself. The Big Bang might also occur in virtue of mathematical reasons. Now, everything is ready for the Big Bang. There are time and energy, though they are not "activated" physically yet. This will be done by choice, which exists, too. The choice means zero entropy and thus infinite temperature at any finite energy, and even possibly at zero energy. The infinite temperature generates symmetry breakings (such as the Higgs mechanism), and particularly breaks the symmetry of the two directions of time. The latter symmetry breaking starts time at the moment: t=0. The nothing explodes (or "Nothing explodes") by itself by taking away, as the History of Being.

The creation might be a decrease rather than an increase. The common point of view surrounding the creation or the being is the opposite. Creation should add rather than take away. The being should ostensibly be more than nothing. On the contrary, the creation is not an increase of nothing, but the decrease of nothing: it is a deficiency in relation to nothing. An image of this could be a sculptor who takes away from the stone with his chisel.

Time and its "arrow" take away, for the other direction of time is removed. Time and its "arrow" are the way from that diminishing or incompleteness to nothing. One may represent the nothing as the unification of both directions of time. However, only the one, forward in time, is real. The other one, backward in time, is taken away from the nothing. After the one direction of time has been taken away from that nothing, what remains is the being. If one could add the reverse direction of time to the being, only the nothing would be obtained.

The concept of transformation into nothing exists in physics as that of "annihilation". "Annihilation" in physics means the fusion of a particle and its antiparticle into light. So, the light (electromagnetic radiation) is the way for us to see the nothing from our viewpoint of the being (i.e. less than nothing). This is the reason for the nothing to be regarded as something: namely as light, but only from our point of view, which is that of "less than nothing". One might try to interpret some ideas about the "Creation", borrowed from the Bible (Genesis 1: 3-4), from a physics point of view: "And God said, "Let there be light," and there was light. And God saw that the light was good. And God separated the light from the darkness" [16].

Our reading of the "light" in both Bible and the theory of relativity is the following: we see the nothing as light because we ourselves are less than nothing. Indeed, the light is an absolute upper border or limit for all being, just as the theory of relativity states. To be nothing, to be an upper border, is only another way of saying that the being is "negative", i.e. less than nothing. According to the Bible (John 1:1-4): "In the beginning was the Word, and the Word was with God, and the Word was God. He was in the beginning with God. All things were made through him, and without him was not any thing made that was made" [17]. Our reading of the "Word" in both the Bible and the theory of quantum information is: the "Word" is information, particularly quantum information. Ontologically, information, being measured by units of bits, is the quantity of "taking away" from the nothing for the being to be created. Indeed, a bit is the elementary choice between two equally probable alternatives, and thus "taking away" one of them: the other is the chosen one.

Time and information are linked to each other intimately. Information is the quantity of choices measured in units of elementary choices, i.e. bits. Time in turn is the result of choices: the successive series of all chosen alternatives. The first crucial and mathematically necessary choice is the choice of time itself, or in other words, the choice of the direction of time, or the "arrow of time". Information (the quantity of choices), and time (the series of all the results of those choices) are closely linked.

[16] Cited according to the King James Version:
https://www.biblegateway.com/passage/?search=Genesis+1%3A3-4&version=KJV
[17] Cited according to the King James Version:
https://www.biblegateway.com/passage/?search=John+1&version=KJV

Conclusions:

Conclusions as negations:

The state of “nothing” is not stable. The physical nothing is not a general vacuum. The being is less than nothing. The creation is taking away from the nothing. Time is the destruction of symmetry. The creation does not need any (external) cause.

Conclusions as statements:

The state of nothing passes spontaneously (by itself) into the state of being. This represents the “creation”. The transition of nothing into being is mathematically necessary. The choice (which can be interpreted philosophically as “free will”) appears necessarily because of mathematical reasons. The choice generates asymmetry, which is the beginning of time and therefore of the physical word. Information is the quantity of choices, and is intimately linked to time.

References:

Abachi, S. et al. (D0 Collaboration) (1995) Search for High Mass Top Quark Production in pp Collisions at √s = 1.8 TeV. *Physical Review Letters* 74(13), 2422–2426.

Abe, F. et al. (CDF Collaboration) (1995) Observation of Top Quark Production in pp Collisions with the Collider Detector at Fermilab. *Physical Review Letters* 74(14), 2626–2631.

Ade, P. A. R. et al. (Planck Collaboration) (2016) Planck 2015 results. XIII. Cosmological parameters. *Astronomy and Astrophysics* 594, A13(63).

Anderson, P. W. (1963) Plasmons, Gauge Invariance, and Mass. *Physical Review* 130(1), 439 – 442.

Banerjee, S. et al. (2005) Cosmological dark energy from the cosmic QCD phase transition and colour entanglement. *Physics Letters B* 611(1-2), 27-33.

Bell, J. S. (1955) Time reversal in field theory. *Proceedings of the Royal Society of London A* 231(1187), 479-495.

Bond, H.E. et al. (2013) HD 140283: A Star in the Solar Neighborhood that Formed Shortly After the Big Bang. *The Astrophysical Journal Letters* 765 (1): L12.

Born, M. (1969) *Albert Einstein Max Born Brief-wechsel 1916 – 1955* (kommentiert von Max Born). München: Nymphenburger, p. 118 (Brief № 48/29.04.1924).

Chamberlain, J. W., Aller, L. H. (1951) The Atmospheres of A-Type Subdwarfs and 95 Leonis. *Astrophysical Journal* 114(1), 52-72.

Conway, J., Kochen, S. (2006) The Free Will Theorem. *Foundations of Physics* 36(10), 1441-1473.

Conway, J., Kochen, S. (2009) The Strong Free Will Theorem. *Notices of the AMS* 56(2), 226-232.

Gamow, G. (1970) *My world line: an informal autobiography.* New York: Viking Press.
Descartes, R. (1641) *Meditations on First Philosophy* with Selections from the Objections and Replies (transl. M. Moriarty). "Oxford World's Classics". Oxford: University Press, 2008.

Einstein, A. (1918) Prinzipielles zur allgemeinen Relativitätstheorie. *Annalen der Physik* 55(4): 241-244.

Einstein, A. Podolsky, B., and Rosen, N. (1935) Can Quantum-Mechanical Description of Physical Reality Be Considered Complete? *Physical Review* 47(10), 777-780.

Einstein, A., Rosen, N. (1935) The Particle Problem in the General Theory of Relativity. *Physical Review* 48 (1): 73–77.

Englert, F., Brout, R. (1964) Broken symmetry and the mass of gauge vector mesons. *Physical Review Letters* 13(9), 321-323.

Gilbert, W. (1964) Broken Symmetries and Massless Particles. *Physical Review Letters* 12(25), 713-714.

Glashow, S. L. (1961) Partial symmetries of weak interactions. *Nuclear Physics* 22(4): 579-588.

Goldstone, J., Salam, A., and Weinberg, S. (1962) Broken symmetries. *Physical Review* 127(3), 965-970.

Gorham, G. (2007) Descartes on Time and Duration. *Early Science and Medicine*, 12(1): 28-54.

Gorham, G. (2008) Descartes on God's Relation to Time. *Religious Studies*, 44(4), 413-431.

Guralnik, G. S., Hagen, C. R. and Kibble, T. W. B. (1964) Global conservation laws and massless particles. *Physical Review Letters* 13(20), 585-587.

Heidegger, M. (1927) *Sein und Zeit*. Gesamtausgabe, Bd. 2, Frankfurt AM: Vittorio Klostermann, 1977.

Higgs, P. W. (1964). Broken symmetries and the masses of gauge bosons. *Physical Review Letters* 13(16), 508-509.

Higgs, P. W. (1964a). Broken symmetries, massless particles and gauge fields. *Physics Letters* 12(2), 132-133.

Higgs, P. W. (1966). Spontaneous symmetry breakdown without massless bosons. *Physical Review* 145(4), 1156-1163.

Hoffman, J., Rosenkrantz, G.S. (2010) *Substance, its nature and existence*. London: Routledge.

Husserl, E. (1931) *Cartesianische Meditationen und Pariser Vorträge*. Den Haag: Nijhoff, 1950.

Jensen, K., Karch, A. (2013) Holographic Dual of an Einstein-Podolsky-Rosen Pair has a Wormhole. *Physical Review Letters* 111(21), 211602(6).

Lemaître, G. (1927) Un univers homogène de masse constante et de rayon croissant, rendant compte de la vitesse radiale des nébuleuses extra-galactiques. *Annales de la Société scientifique de Bruxelles, Sèrie A*, 47, 49-59.

Lemaître, G. (1946) *L'Hypothèse de l'Atome Primitif: Essai de cosmogonie*. Neuchâtel: Griffon; Paris: Dunod, 1946.

Lemaître, G. (1931) The Beginning of the World from the Point of View of Quantum Theory. *Nature* 127(3210), 706.

Lewkowycz, A., Maldacena, J. J. (2014) Exact results for the entanglement entropy and the energy radiated by a quark. *Journal of High Energy Physics* 2014(5), 25.

Luders, G. (1954) On the Equivalence of Invariance under Time Reversal and under Particle-Antiparticle Conjugation for Relativistic Field Theories. *Kongelige Danske Videnskabernes Selskab. Matematisk-Fysiske Meddelelser* 28(5), 1-17.

Molaro, P. (1987) Upper limit to the boron abundance in the population II star HD 140283. *Astronomy and Astrophysics* 183(2), 241-246.

Noether, E. (1918) Invariante Variationsprobleme. *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse* 1918, 235-257.

Pauli,Riess, A. et al. (Supernova Search Team), 1998, Observational evidence from supernovae for an accelerating universe and a cosmological constant. Astronomical Journal, 116 (3): 1009–38. W. (1955) Exclusion principle, Lorentz group and reflection of space-time and charge. In: W. Pauli (ed.) *Niels Bohr and the development of physics*. New York: McGraw-Hill, pp. 30–51.

Penchev, V. (2013) The Kochen – Specker theorem in quantum mechanics: A philosophical comment. *Philosophical Alternatives* 2013(1), 67-77 (Part 1); 2013(3), 74-83 (Part 2).

Riess, A. et al. (Supernova Search Team) (1998) Observational evidence from supernovae for an accelerating universe and a cosmological constant. *Astronomical Journal* 116 (3): 1009–38.

Schrödinger, E. (1935) Die gegenwärtige situation in der Quantenmechanik. *Die Naturwissenschaften* 23(48), 807-812; 23(49), 823-828; 23(50), 844-849.

Secada, J.E.K. (1990) Descartes on Time and Causality. *The Philosophical Review* 99(1), 45-72.

Spite, F., Spite, M (1982) Abundance of lithium in unevolved halo stars and old disk stars - Interpretation and consequences. *Astronomy & Astrophysics* 115 (2), 357–366

Streater, R. F. (1965) Spontaneously broken symmetry in axiomatic theory. *Proceedings of the Royal Society London A* 287(1411): 510-518.

Trimble, V. (1987) Existence and nature of dark matter in the universe. *Annual Review of Astronomy and Astrophysics* 25, 425–472.

Wippel, J. F. (2011) *The ultimate why question: why is there anything at all rather than nothing whatsoever?* Washington, D.C.: Catholic University of America Press.

Wiseman, H. (2015) Quantum physics: Death by experiment for local realism. *Nature* 526(7575), 649–650.

Бронштейн М. П. (1936) Квантование гравитационных волн. *Журнал экспериментальной и теоретической физики* 6, 195—236.

Мамардашвили, М. (1981) *Картезианские размышления (январь 1981 г.)*. (Под редакции Ю. П. Сенокосова.) Москва: Прогресс, 1993.